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Kawadu et al.

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(54) **PULSE ROCKET MOTOR INCLUDING A DIVIDING SHEET FOR SEPARATING THE FIRST GRAIN PROPELLANT FROM THE SECOND GRAIN PROPELLANT**

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F02K 9/28 (2006.01)
F02K 9/32 (2006.01)
F02K 9/36 (2006.01)

(52) **U.S. Cl.**
CPC ... ***F02K 9/08*** (2013.01); *F02K 9/28* (2013.01); *F02K 9/32* (2013.01); *F02K 9/36* (2013.01)

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CPC F02K 9/08; F02K 9/12; F02K 9/28; F02K 9/32; F02K 9/36; F02K 9/34; F02K 9/343; F02K 9/346
USPC 60/253, 254, 255, 256
See application file for complete search history.

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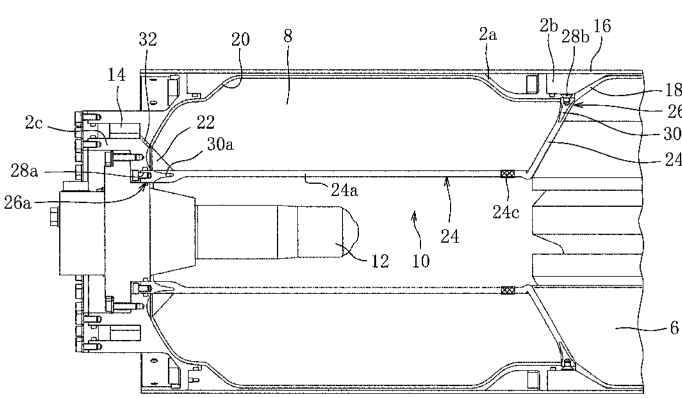
(57) **ABSTRACT**

A pulse rocket motor has a hollow cylinder-like first grain situated in a rear section of a pressure vessel; a first igniter for igniting the first grain; a hollow cylinder-like second grain situated in a front section of the pressure vessel; a second igniter for igniting the second grain; and a dividing sheet member that covers the second grain within the pressure vessel. The dividing sheet member includes a dividing sheet expanding at least along the inner circumferential surface of the second grain and holders formed integrally with the dividing sheet at both ends of the dividing sheet by cure adhesion and attached to the pressure vessel. The dividing sheet includes a brittle portion that expands along the inner circumferential surface of the second grain through a rear end face of the second grain and is more brittle than other portions.

8 Claims, 10 Drawing Sheets



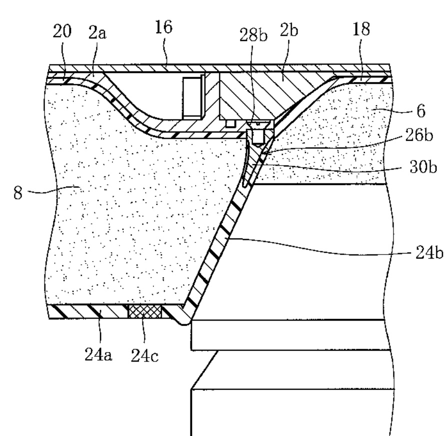


FIG. 1

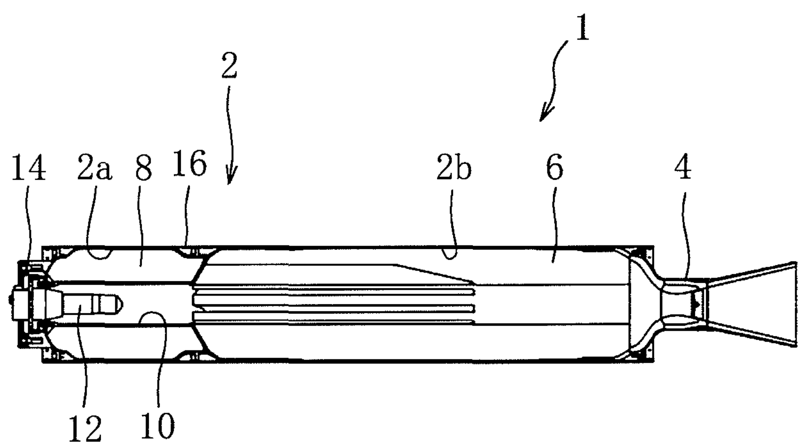


FIG. 2

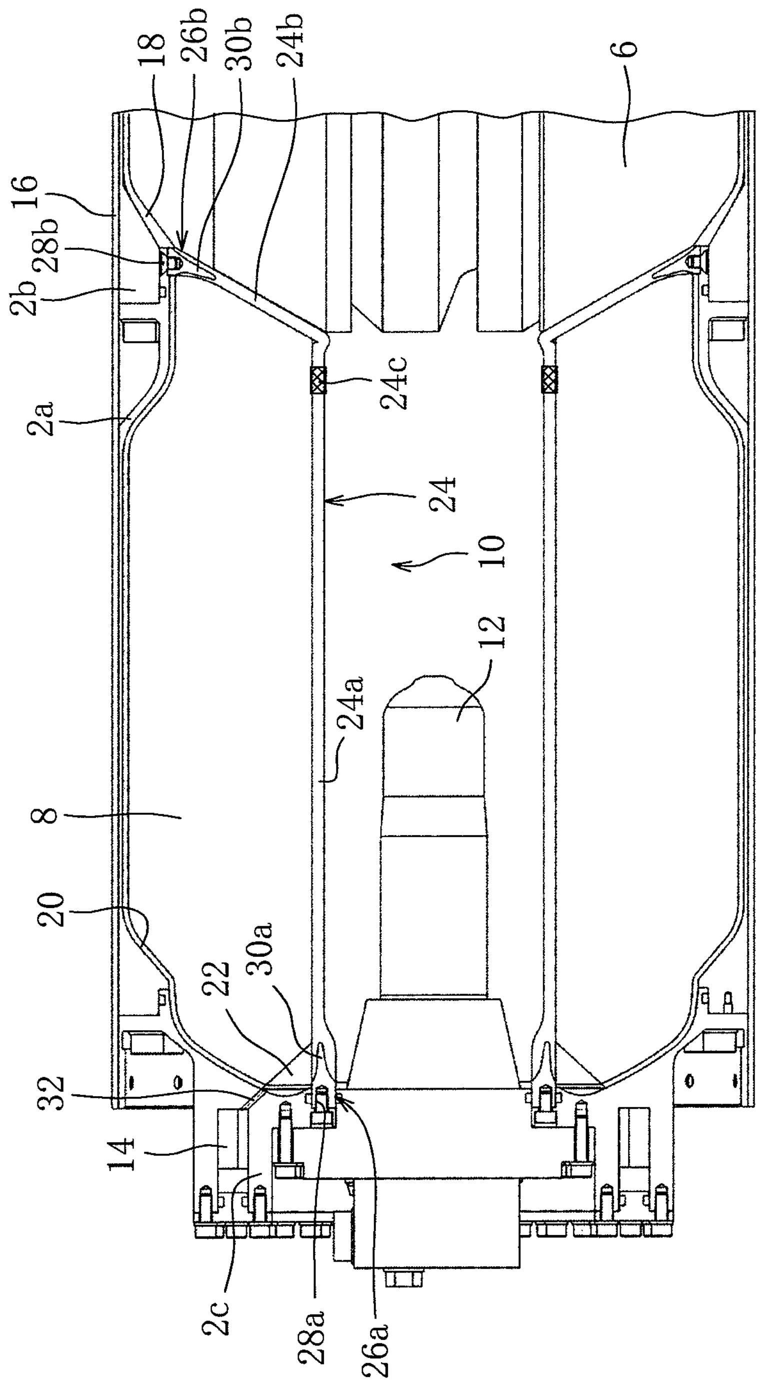

18
26b
30b
24b
6
16
28b
2b
24c
2a
24
10
12
24a
8
20
30a
22
32
14
2c
28a
26a

FIG. 3

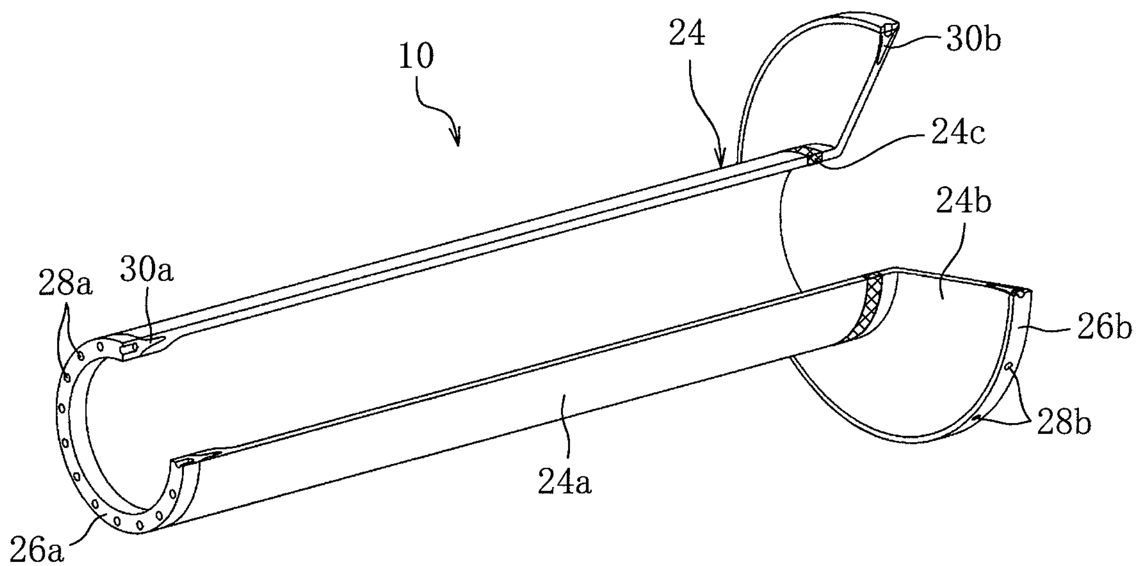


FIG. 4

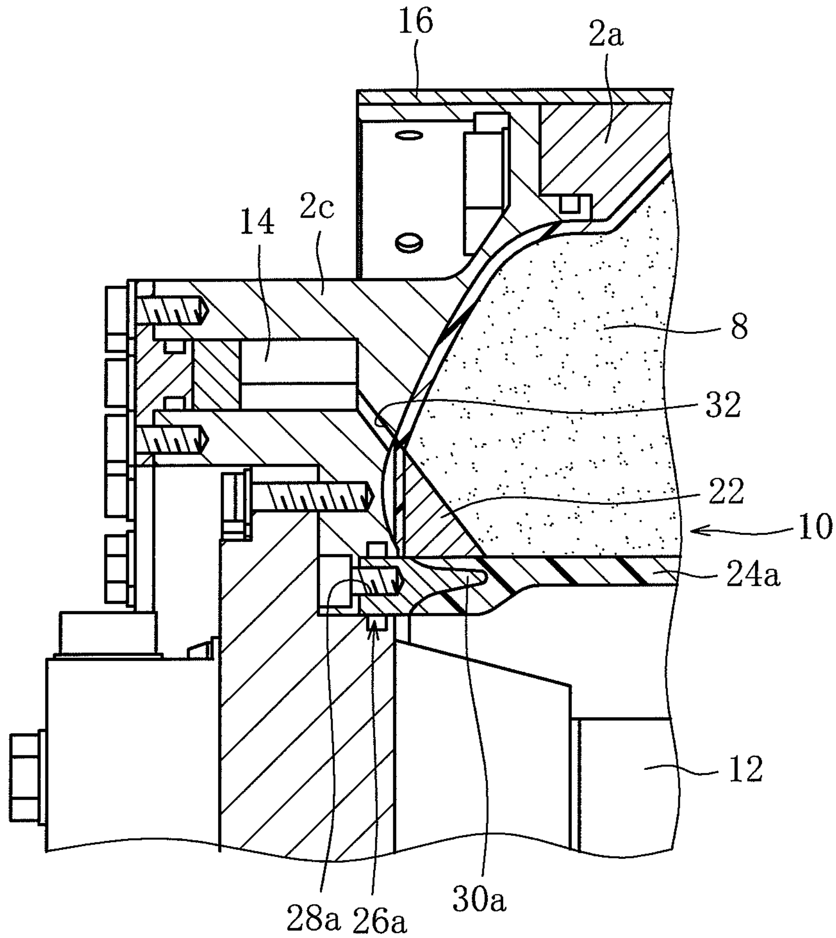


FIG. 5

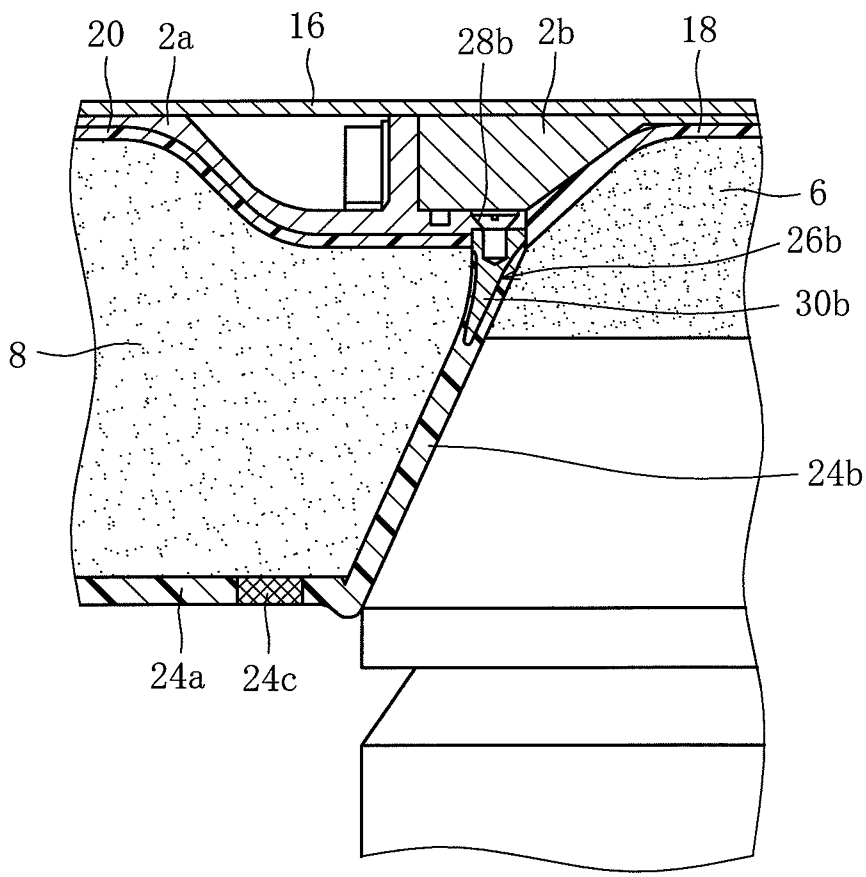


FIG. 6A

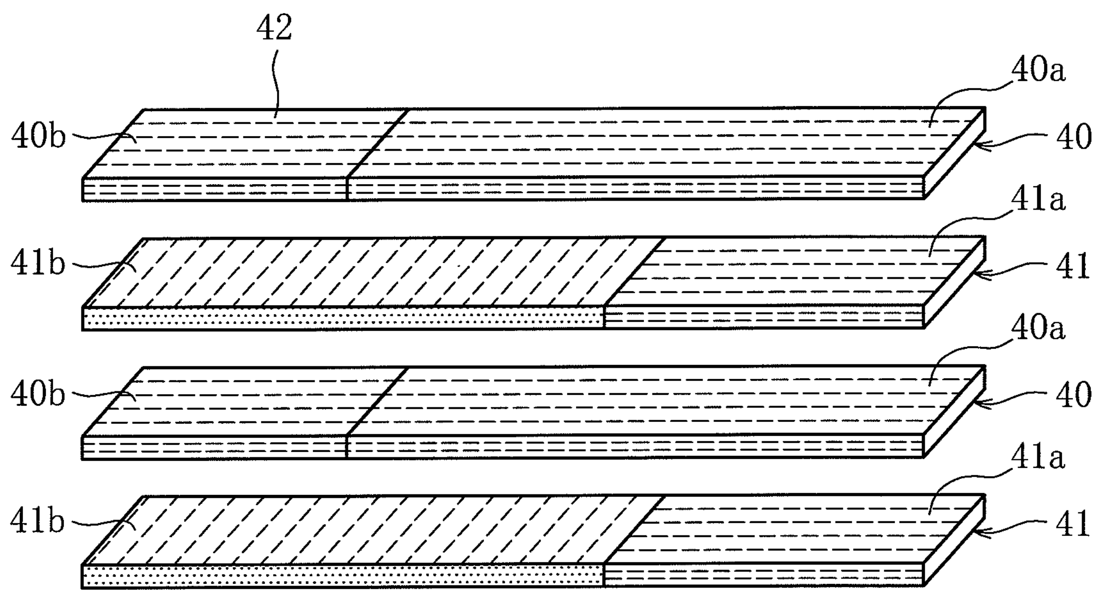

42
40a
40b
40
41a
41b
41
40a
40b
40
41a
41b
41

FIG. 6B

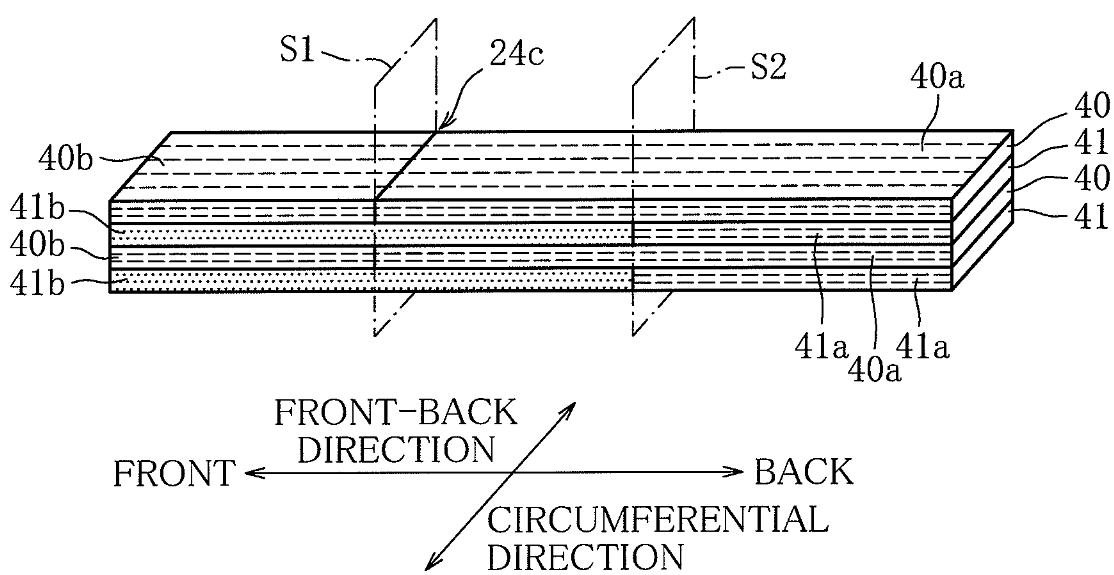

S1
24c
S2
40a
40b
40
41
40
41
41b
40b
41b
41a
40a
41a
FRONT-BACK
DIRECTION
FRONT
BACK
CIRCUMFERENTIAL
DIRECTION

FIG. 7A

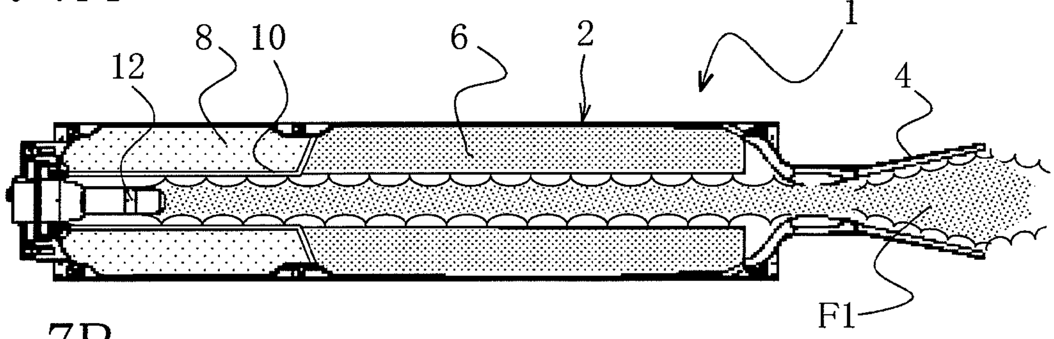


FIG. 7B

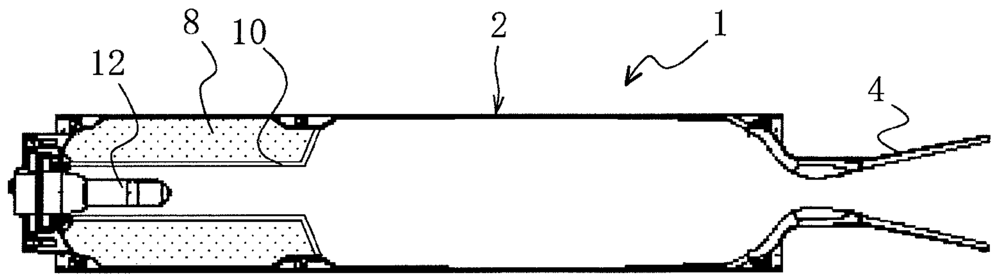


FIG. 7C

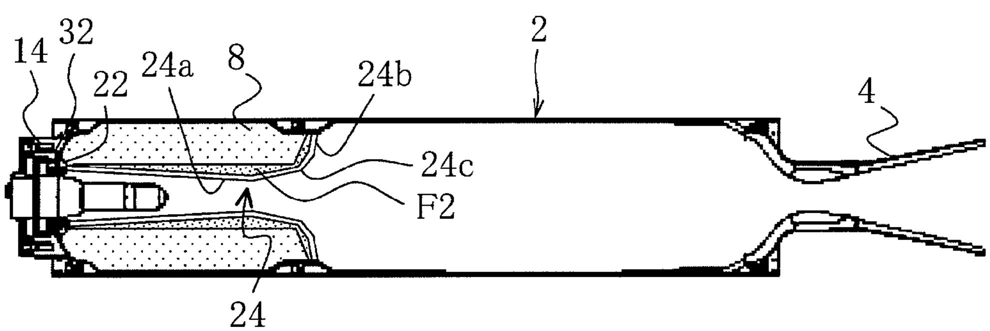


FIG. 7D

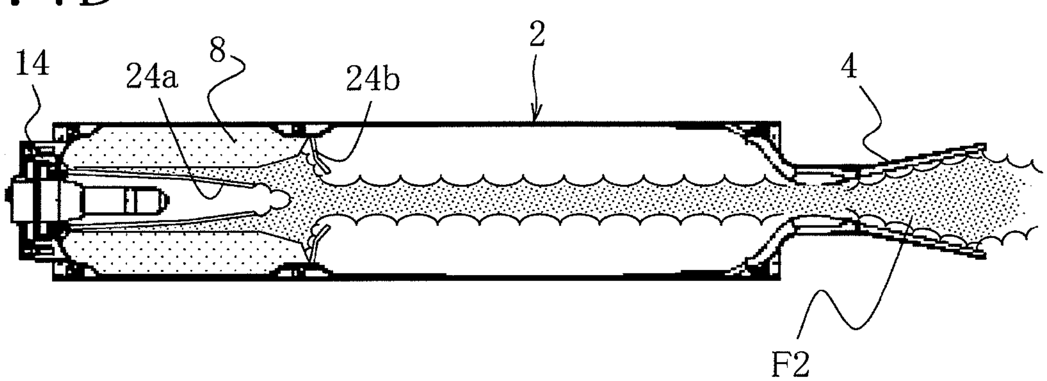


FIG. 8A

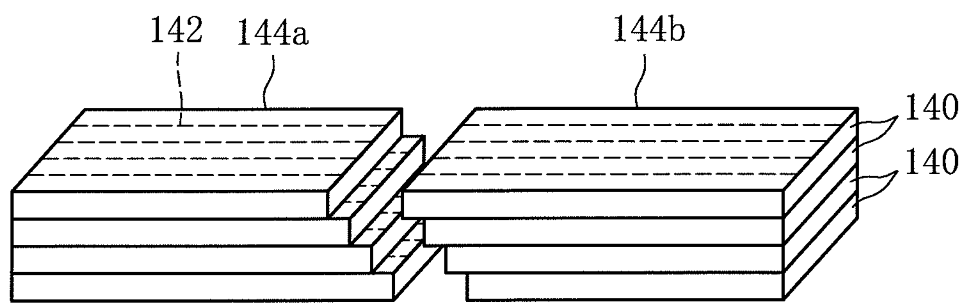

142
144a
144b
140
140

FIG. 8B

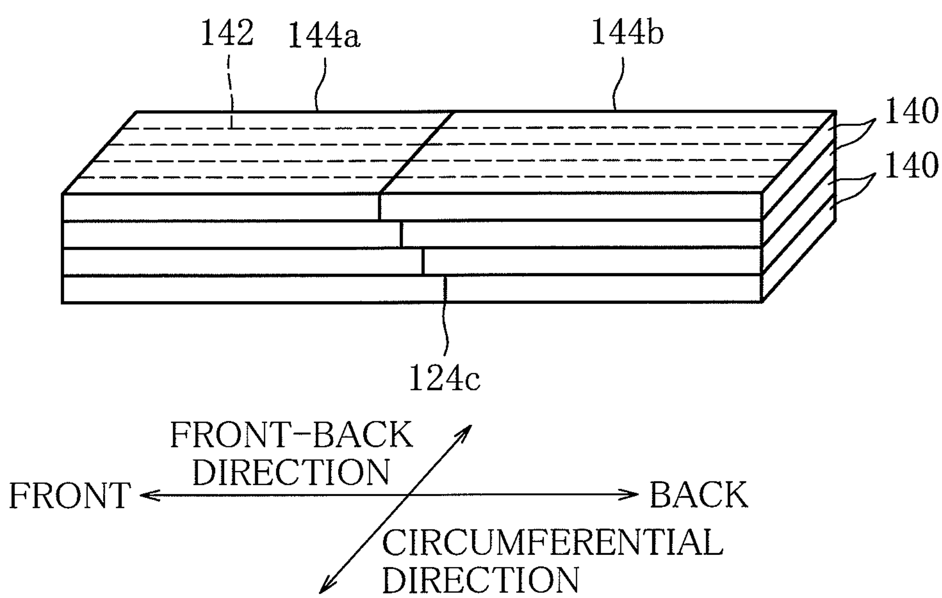

142
144a
144b
140
140
124c
FRONT-BACK DIRECTION
FRONT
BACK
CIRCUMFERENTIAL DIRECTION

FIG. 9

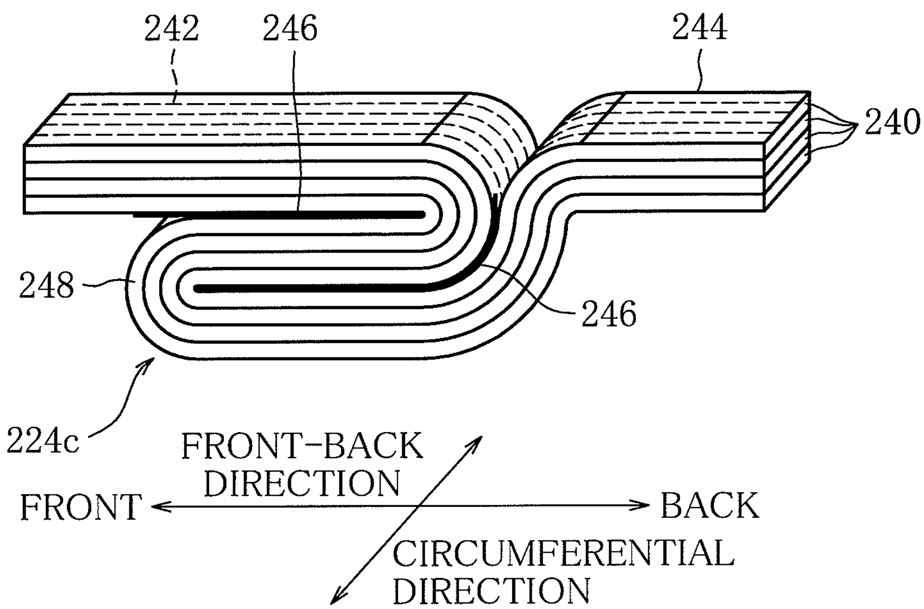

242
246
244
240
248
246
224c
FRONT-BACK
DIRECTION
FRONT
BACK
CIRCUMFERENTIAL
DIRECTION

FIG. 10

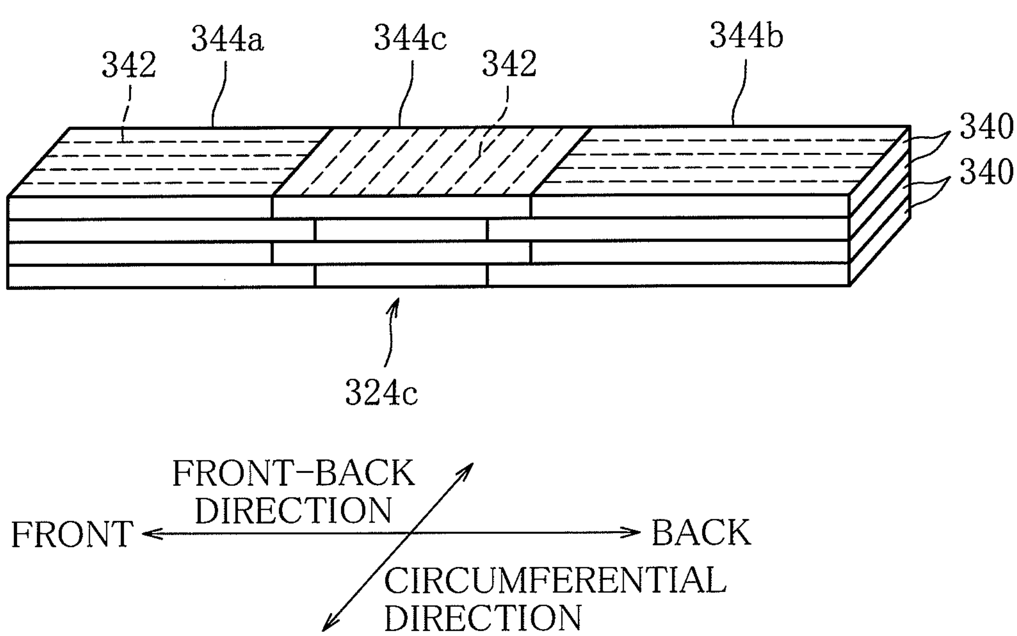

342
344a
344c
342
344b
340
340
324c
FRONT-BACK
DIRECTION
FRONT
BACK
CIRCUMFERENTIAL
DIRECTION

FIG. 11

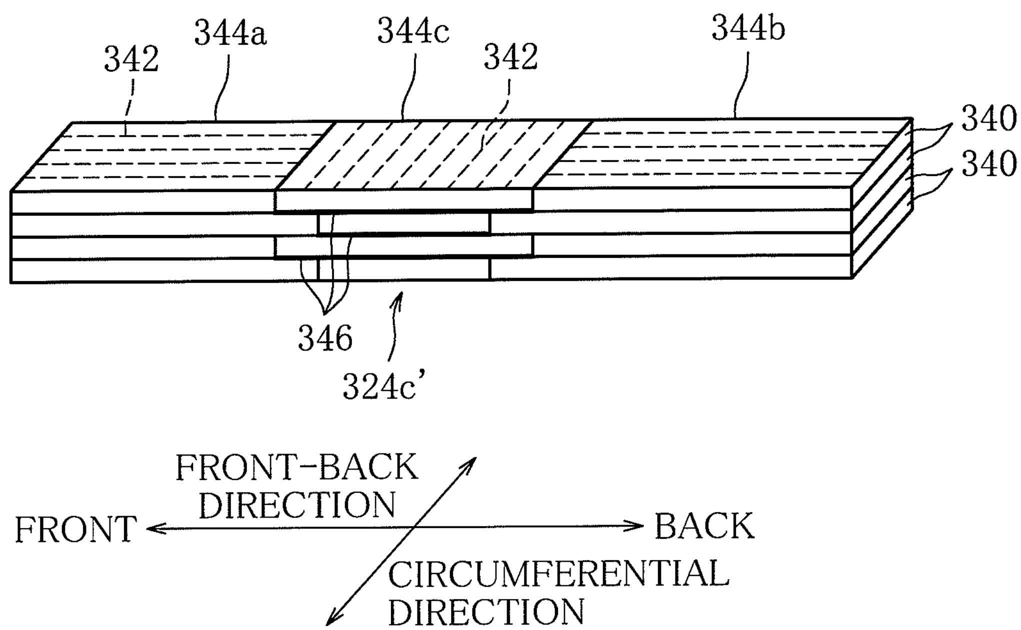
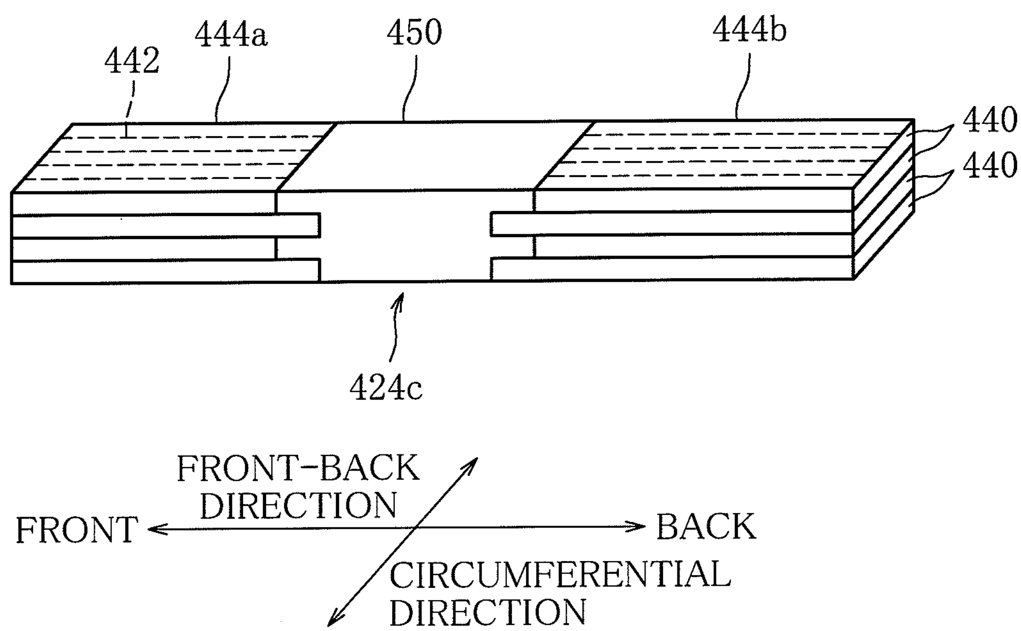

342
344a
344c
342
344b
340
340
346
324c'
FRONT-BACK
DIRECTION
FRONT
BACK
CIRCUMFERENTIAL
DIRECTION

FIG. 12


442
444a
450
444b
440
440
424c
FRONT-BACK
DIRECTION
FRONT
BACK
CIRCUMFERENTIAL
DIRECTION

PULSE ROCKET MOTOR INCLUDING A DIVIDING SHEET FOR SEPARATING THE FIRST GRAIN PROPELLANT FROM THE SECOND GRAIN PROPELLANT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a pulse rocket motor with a plurality of solid fuels.

2. Description of the Related Art

A pulse rocket motor has a configuration in which two or more grains are placed in a single pressure vessel so as to be separated from each other by a dividing sheet or wall. This provides the advantage that combustion timing can be differentiated in a solid fuel rocket in which fuel combustion is not easy to stop and restart.

More specifically, a dual pulse rocket motor has been developed, in which a Pulse 1 grain (first grain) is situated in the rear section of a pressure vessel made of a carbon fiber and epoxy resin composition according to the Filament Winding method; a Pulse 2 grain (second grain) in the front section of the pressure vessel; and a barrier insulator (dividing sheet) is disposed between these grains (International Publication No. WO95/30084).

In the dual pulse rocket motor disclosed in International Publication No. WO95/30084, a fore insulator is situated between the pressure vessel and the Pulse 2 grain, and an aft insulator between the pressure vessel and the Pulse 1 grain. The fore, aft and barrier insulators are synthetic rubber made of EPDM (ethylene propylene diene monomer). These insulators are partially overlapped and adhered to each other.

According to the method of producing the dual pulse rocket motor described in International Publication No. WO95/30084, components are placed in order from before backwards. First of all, the fore insulator is placed in the inner surface of the pressure vessel, and the Pulse 2 grain is casted and hardened under vacuum. Secondly, the barrier insulator is attached to the Pulse 2 grain and the fore insulator, and the fore insulator is cut off. The aft insulator is attached to the barrier insulator, and the Pulse 1 grain (first grain) is injected and hardened. The insulators have inner surfaces covered with adhesive liners, which are adhered to their respective grains.

To produce the pressure vessel disclosed in International Publication No. WO95/30084, the carbon fiber and epoxy resin composition is molded directly around the grains according to the Filament Winding method. Pressure vessels thus made from resin have lower rigidity than those made from metal. Furthermore, the production method that molds a pressure vessel directly around grains requires the process of covering the fore, aft and barrier insulators with adhesive liners and thus bonding the insulators to the grains, which complicates the production process.

During the combustion of the Pulse 1 grain, the barrier insulator separating the Pulse 1 grain from the Pulse 2 grain is required to prevent flame from being transferred to the Pulse 2 grain. Due to aging degradation, however, there is the possibility that the barrier insulator and the fore insulator are detached from each other in their adhered region, and thus that the barrier insulator fails to prevent the flame transfer.

During the combustion of the Pulse 2 grain, it is also required that the barrier insulator should be broken at a certain position but never fall in order to prevent the barrier insulator from falling and blocking a nozzle. In this respect, International Publication No. WO95/30084 suggests breaking the barrier insulator in the adhered region between the fore insulator and the barrier insulator. It is not easy, however, to break the barrier insulator with proper timing because the setting of breaking strength by adhesion is difficult. Since the insulators are adhered to the grains, the barrier insulator is constrained from being detached from the grain at the time of the combustion of the Pulse 2 grain, which is a problem from the viewpoint of unfailing working.

The invention has been made to solve the foregoing problem. It is an object of the invention to provide a pulse rocket motor that surely prevents flame from being transferred to a second grain at the time of first pulse and reliably carries out second pulse with a simple configuration.

SUMMARY OF THE INVENTION

An aspect of the present invention is directed to a pulse rocket motor including a first grain having a hollow cylinder-like shape and situated in a rear section of a pressure vessel; a first igniter that ignites the first grain; a second grain having a hollow cylinder-like shape and situated in a front section of the pressure vessel; a second igniter that ignites the second grain; and a dividing sheet member that covers the second grain within the pressure vessel. The dividing sheet member has a dividing sheet expanding at least along an inner circumferential surface of the second grain; and holders formed integrally with the dividing sheet at both ends of the dividing sheet by cure adhesion and attached to the pressure vessel. The dividing sheet includes a brittle portion that expands along the inner circumferential surface of the second grain through a rear end face of the second grain and is more brittle than other portions.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinafter and the accompanying drawings which are given by way of illustration only, and thus, are not limitative of the present invention, and wherein:

FIG. **1** is a sectional view of the entire configuration of a pulse rocket motor according to a first embodiment;

FIG. **2** is an enlarged sectional view of a main section shown in FIG. **1**;

FIG. **3** is a perspective view of a dividing sheet member partially broken away;

FIG. **4** is an enlarged sectional view of a front section shown in FIG. **2**;

FIG. **5** is an enlarged sectional view of a rear section shown in FIG. **2**;

FIG. **6**A is a fragmentary sectional view showing a configuration of a brittle portion of the dividing sheet arranged in the pulse rocket motor according to the first embodiment;

FIG. **6**B is a fragmentary sectional view showing in a layered state the configuration of the brittle portion of the dividing sheet arranged in the pulse rocket motor according to the first embodiment;

FIG. **7**A is a view showing the working of the pulse rocket motor according to the invention during first pulse;

FIG. **7**B is a view showing the working of the pulse rocket motor according to the invention at the time when the first pulse is finished;

FIG. **7**C is a view showing the working of the pulse rocket motor according to the invention at an initial stage of second pulse;

FIG. **7**D is a view showing the working of the pulse rocket motor according to the invention at a late stage of the second pulse;

FIG. **8**A is a fragmentary sectional view showing in an exploded state a configuration of a brittle portion of a dividing sheet arranged in a pulse rocket motor according to a second embodiment;

FIG. **8**B is a fragmentary sectional view showing in a layered state the configuration of the brittle portion of the dividing sheet arranged in the pulse rocket motor according to the second embodiment;

FIG. **9** is a fragmentary sectional view showing a configuration of a brittle portion of a dividing sheet arranged in a pulse rocket motor according to a third embodiment;

FIG. **10** is a fragmentary sectional view showing a configuration of a brittle portion of a dividing sheet arranged in a pulse rocket motor according to a fourth embodiment;

FIG. **11** is a fragmentary sectional view showing a modification example of the brittle portion shown in FIG. **10**; and

FIG. **12** is a fragmentary sectional view showing a configuration of a brittle portion of a dividing sheet arranged in a pulse rocket motor according to a fifth embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the invention will be described below with reference to the attached drawings.

FIG. **1** is a sectional view of the entire configuration of a pulse rocket motor according to a first embodiment. FIG. **2** is an enlarged sectional view showing a main section. FIG. **3** is a perspective view of a dividing sheet member partially broken away. FIG. **4** is an enlarged sectional view of a front section of FIG. **2**. FIG. **5** is an enlarged sectional view of a rear section of FIG. **2**. FIGS. **6**A and **6**B are fragmentary sectional views showing a configuration of a brittle portion of a dividing sheet.

A dual pulse rocket motor **1** shown FIG. **1** has a nozzle **4** arranged in a rear section of a pressure vessel **2**. Inside the dual pulse rocket motor **1**, a first grain **6** and a second grain **8** serving as solid fuel are arranged in rear and front sections, respectively. The second grain **8** is covered with a dividing sheet member **10**. Attached to a front section of the pressure vessel **2** are a first igniter **12** for igniting the first grain **6** and a second igniter **14** for igniting a second grain **8**.

More specifically, the pressure vessel **2** is a bi-split metal motor case and is formed of front and rear cases **2***a* and **2***b* substantially in the shape of cylinders of the same diameter and coaxially jointed together. The front and rear cases **2***a* and **2***b* are jointed together by fastening a rear-end opening edge of the front case **2***a* to a front-end opening edge of the rear case **2***b* with a plurality of bolts. Preferably, the pressure vessel **2** is made of titanium, maraging steel, D6AC steel, chrome molybdenum steel or the like. The outer periphery of the pressure vessel **2** is covered with an external insulator **16**.

The first grain **6** is a grain for first pulse, which is burned first, and has the shape of a hollow cylinder extending in a front-back direction. The first grain **6** is situated in the rear case **2***b* with a rear thermal insulating material **18** there between. The first grain **6** includes a portion extending between the center thereof and the front end thereof in the front-back direction, which have an internal bore whose cross-sectional shape is a star polygon with a plurality of vertices so that combustion area is enlarged. The internal bore leads to the outside through the nozzle **4**. The first grain **6** is a composite grain. The internal bore of the first grain may have a cross-section in the shape of a circle or may have a cross-section in the shape of a star polygon with vertices or the like in a portion extending between the center and the rear end thereof in the front-back direction or in another arbitrary portion.

The second grain **8** is a grain for second pulse, which is later burned, and has the shape of a hollow cylinder extending in the front-back direction. As particularly shown in FIG. **2**, the second grain **8** is situated in the front case **2***a* with a front thermal insulating material **20** there between. The second grain **8** includes an internal bore having a circular cross-section and leading to the internal bore of the first grain **6** through the dividing sheet member **10**. The second grain **8** is a composite grain.

An axial portion of the front section of the second grain **8** is cut away in a conical shape pointing rearwards. The cut-away area is filled with a grain holder **22**. The grain holder **22** has lower density than the second grain **8** and is made of easily-burned material, such as foam material.

The dividing sheet member **10** includes a dividing sheet **24** made of thermal-insulating EPDM rubber, which is attached to the pressure vessel **2** with dividing sheet clamps **26***a* and **26***b* (holders) fixed to both respective ends of the dividing sheet member **10**.

As shown in FIGS. **2** and **3**, the dividing sheet **24** has a substantially funnel-like shape including an inner face **24***a* expanding in the front-back direction along an inner circumferential surface of the internal bore of the second grain **8** to be formed in a cylindrical shape and an end face **24***b* expanding from a rear end of the inner face **24***a* at a slant in a radially outward direction.

The dividing sheet clamps **26***a* and **26***b* have a ring-like shape. A plurality of bolt holes **28***a* and **28***b* are formed in a front face of the dividing sheet clamp **26***a* located near the front end and in an outer circumferential surface of the dividing sheet clamp **26***b* located near the rear end at intervals along a circumferential direction. The dividing sheet member **10** is fastened to the pressure vessel **2** with bolts screwed into the bolt holes **28***a* and **28***b*. Preferably, the dividing sheet clamps **26***a* and **26***b* are metal from the viewpoint of airtightness and heat resistance. However, the dividing sheet clamps **26***a* and **26***b* may be made of Fiber Reinforced Plastics (FRP) or the like as long as they are as airtight and heat-resistant as when being made of metal.

An attachment structure of the dividing sheet **24** and the dividing sheet clamps **26***a* and **26***b* will be explained below in further details with reference to FIGS. **4** and **5**.

As shown in FIG. **4**, the dividing sheet clamp **26***a* located near the front end is provided in a ring-like rear face with a convex portion **30** having a convex cross-section tapered rearwards. The convex portion **30***a* is located inside the front end portion of the inner face **24***a* of the dividing sheet expanding in the front-back direction. The convex portion **30***a* and the inner face **24***a* of the dividing sheet are integrally combined together by cure adhesion. The tip end of the convex portion **30***a* of the dividing sheet clamp **26***a* located near the front end coincides with a rear end of the grain holder **22** as viewed in the front-back direction. The convex portion **30***a* extends over a range of the grain holder **22**.

As shown in FIG. **5**, a convex portion **30***b* having a convex cross-section tapered inwards is formed in the ring-like inner surface of the dividing sheet clamp **26***b* located near the rear end. The convex portion **30***b* is located inside the rear end portion of the end face **24***b* of the dividing sheet expanding in the radial direction. The convex portion **30***b* and the end face **24***b* of the dividing sheet are integrally combined together by cure adhesion. The end face **24***b* is in direct contact with the first grain **6** and the second grain **8** to separate the first grain **6** from the second grain **8**.

The dividing sheet **24** will be described below in details.

As shown in FIGS. **2**, **3** and **5**, in the dividing sheet **24**, a brittle portion **24***c* that is structurally more brittle than other portions is formed near a curved portion between the inner face **24***a* and the end face **24***b*. The brittle portion **24***c* is previously designed to have such strength as to be broken when receiving a combustion pressure equal to or higher than a predetermined value.

FIGS. **6**A and **6**B are fragmentary views showing a configuration of the brittle portion **24***c* in the dividing sheet **24**. The dividing sheet **24** made of EPDM is formed of a rubber layered body that is obtained by stacking a plurality of rubber plates in layers in a thick direction. The rubber plates are formed by mixing short fibers (such as aramid fiber) into crude rubber and compressing the result with a roller. The fibers mixed in the rubber plates form lines in a grain direction that the fibers are compressed by the roller. FIGS. **6**A and **6**B show the direction of alignment of fibers **42** in the rubber plates, namely, grain direction by broken lines for simplicity.

As shown in FIGS. **6**A and **6**B, the dividing sheet **24** in the first embodiment is formed of a four-layer rubber layered body in which first rubber layers **40** and second rubber layers **41** are alternately stacked in a thick direction.

The first rubber layer **40** is formed by butt-jointing a pair of rubber plates **40***a* and **40***b* whose grain direction is the front-back direction of the dividing sheet **24**. The second rubber layer **41** is formed by butt-jointing a rubber plate **41***a* whose grain direction is the front-back direction of the dividing sheet **24** and a rubber plate **41***b* whose grain direction is a circumferential direction (perpendicular to the front-back direction) of the dividing sheet **24**.

The first rubber layers **40** and the second rubber layers **41** are stacked upon one another so that the butt-jointed faces of the first rubber layers **40** lay in the same plane S**1**, and that the rubber plates **41***b* of the second rubber layers **41**, whose grain direction is the circumferential direction, lay in the same plane S**1**. The butt-jointed faces of the rubber plates **40***a*, **40***b*, **41***a* and **41***b* are adhered to each other by cure adhesion, and likewise the layered faces to each other by cure adhesion.

In the cross-section S**1**, the butt-jointed faces of the first rubber layers **40** in which the fibers **42** are cut and the grain direction of the rubber plates **41***b* of the second rubber layers **41** are orthogonal to the front-back direction of the dividing sheet **24**. A portion located in the plane S**1** is easy to split in the front-back direction and thus forms the brittle portion **24***c*.

The rubber plates **40***a* of the first rubber layers **40** in which fibers are aligned in the front-back direction of the dividing sheet **24** lay in the same plane S**2** that coincides with the butt-jointed face of the rubber plates **41***a* and **41***b* of the second rubber layers **41**. A portion between the butt-jointed faces of the first and second rubber layers **40** and **41**, that is, between the planes S**1** and S**2**, has strength required for the brittle portion because of shear stress produced by adhesion between the layered faces. As the result of the above-described configuration, the brittle portion **24***c* endures the combustion pressure of the first pulse and is broken at one place of the portion located in the plane S**1** at the time of the second pulse.

Referring to FIG. **2**, the first igniter **12** is fixed to be located in the axial portion of a dividing wall **2***c* that blocks the front section of the pressure vessel **2**. The first igniter **12** is protruding rearwards within the internal bore of the second grain **8**, namely, within the inner face **24***a* of the dividing sheet member **10**. In the dividing wall **2***c*, a plurality of ignition holes **32** leading to the grain holder **22** are formed to be located at different phases. Second igniters **14** are situated so as to be connected to the ignition holes **32**. The second igniters **14** have a ring-like hollow, which is loaded with ignition charge. The second igniters **14** are toroidal igniters that function to transfer the flame of the ignition charges to all the ignition holes **32** at the time of ignition of the second pulse.

The operation of the pulse rocket motor of the invention thus configured will be described below.

FIGS. **7**A to **7**D show the working of the pulse rocket motor of the invention. The working of the pulse rocket motor will be described with reference to these drawings. FIGS. **7**A to **7**D are simplified schematic views of the pulse rocket motor shown in FIGS. **1** to **5**.

FIG. **7**A shows the first pulse. When the first igniter **12** is ignited, the combustion of the first grain **6** is begun. The combustion starts from the inner circumferential surface of the internal bore of the first grain **6**. Combustion gas F**1** passes through the nozzle **4** and is injected into air. The dual pulse rocket motor **1** is thus provided with propulsion by the first pulse.

At this time, the ignition flame of the first igniter **12** and the combustion gas F**1** of the first grain **6** do not enter into the second grain **8** because the second grain **8** is covered with the dividing sheet member **10** integrally formed to expand from the dividing sheet clamps **26***a* and **26***b* through the dividing sheet **24**. Especially, the grain holder **22** having lower rigidity than the second grain **8** is provided in the axial portion of the front portion of the second grain **8**. The convex portion **30***a* of the dividing sheet clamp **26***a* located at the front end of the dividing sheet member **10** extends nearer the axis in relation to the grain holder **22**. For that reason, the pressure provided from the combustion gas F**1** is received by the metal dividing sheet clamp **26***a* having sufficient strength, and thus does not deform the dividing sheet member **10**.

As shown in FIG. **7**B, when the first grain **6** is thoroughly combusted, the first pulse is finished.

FIG. **7**C shows the second pulse. When the second igniters **14** are ignited with arbitrary timing, the ignition fire reaches the grain holder **22** through the ignition holes **32**, and the ignition holder **22** is first combusted. Once the grain holder **22** is combusted, the second grain **8** starts being combusted from the inner surface thereof towards the rear end face, and combustion gas F**2** is created between the inner surface of the second grain **8** and the dividing wall member **10**. The dividing sheet **24** then receives combustion pressure and expands towards the second grain **8**, thereby being deformed in the inward direction of the pressure vessel **2**.

As shown in FIG. **7**D, if the deformation of the dividing sheet **24** progresses, the dividing sheet **24** is broken in the brittle portion **24***c* that is more brittle than other portions. After the breakage, the combustion gas F**2** passes through the nozzle **4** and is injected into air. The combustion gas F**2** buckles the inner face **24***a* of the dividing sheet **24** towards the axis and bends the end face **24***b* in the rearward direction. The surfaces of the inner and end faces **24***a* and **24***b* of the dividing sheet **24** are burned off by the combustion gas F**2**. The dividing sheet **24** is designed to keep an unburned layer of a certain thickness in order to retain the strength that is required to avoid a harmful fall of the dividing sheet **24**. The dividing sheet **24** therefore does not fall and cause a problem such as the blocking of the nozzle **4** or the like. When the second grain **8** is thoroughly combusted, the second pulse is finished.

As described above, in the dual pulse rocket motor **1** of the embodiment, the dividing sheet **24** of the dividing sheet member **10** is chemically and firmly adhered by cure adhesion to the dividing sheet clamps **26***a* and **26***b*. The dividing sheet member **10** is integrally formed to expand from the dividing sheet clamps **26***a* and **26***b* through the dividing sheet **24**, thereby covering the second grain **8**. This makes it possible to avoid risks including detachment attributable to aging degradation and reliably prevent the flame transfer to the second grain **8** at the time of the first pulse.

In the dividing sheet **24**, the brittle portion **24***c* that is more brittle than other portions is formed around the curved portion between the inner face **24***a* and the end face **24***b*. Accordingly, when the dividing sheet **24** receives a combustion pressure of a predetermined or higher value at the time of the second pulse, the dividing sheet **24** is broken in the brittle portion **24***c* without fail.

The brittle portion **24***c* of the first embodiment has a configuration in which the butt-jointed faces of the first rubber layers **40** and the rubber plates **41***b* whose grain direction is the circumferential direction in the second rubber layers **41** are located on the same plane S**1**. The brittle portion **24***c* therefore endures the combustion pressure of the first pulse and is on the other hand broken accurately at one place of the portion located in the plane S**1** at the time of the second pulse.

Since the dividing sheet **24** is credibly detached in the brittle portion **24***c* provided in the dividing sheet **24** of a portion covering the second grain **8**, the dividing sheet **24** does not fall and block the nozzle **4**. Furthermore, the dividing sheet **24**, after being detached, reliably carries out the second pulse without blocking the combustion gas F**2** flowing from the second grain **8**. The brittle portion **24***c* of the dividing sheet **24** does not have to be formed in the curved portion between the inner face **24***a* and the end face **24***b*, and may be formed in an arbitrary place of the dividing sheet **24**. The brittle portion **24***c* has a simple configuration in which the rubber layers **40** and **41** obtained by butt-jointing the rubber plates **40***a*, **40***b*, **41***a* and **41***b* are stacked in layers and adhered to each other by cure adhesion. At the same time, the brittle portion **24***c* enables the dividing sheet **24** to maintain integrity. This way, the brittle portion **24***c* is capable of preventing the flame transfer to the second grain **8** at the time of the first pulse as mentioned above.

Since the dividing sheet member **10** is attached to the pressure vessel **2** with the dividing sheet clamps **26***a* and **26***b* formed integrally with the dividing sheet **24**, it is not required to adhere the dividing sheet **24** to the grains **6** and **8**, which facilitates the production. Moreover, since the grains **6** and **8** do not adhere to the dividing sheet **24**, the dividing sheet **24** is easily detached from the second grain **8** at the time of the second pulse, and the second pulse can be reliably carried out.

In the dividing sheet clamp **26***a* located near the front end, the convex portion **30***a* that is adhered to the dividing sheet **24** by cure adhesion extends rearwards at least over a range of the grain holder **22**, so that the combustion pressure created during the first pulse is received by the metal dividing sheet clamp **26***a*. It is then possible to secure strength of a region of the dividing sheet member **10**, which is in contact with the grain holder **22**, and prevent the deformation and breakage from occurring in the region.

With this simple configuration, the dual pulse rocket motor of the first embodiment unfailingly prevents flame from being transferred to the second grain **8** at the time of the first pulse and reliably carries out the second pulse.

This is the end of the description of the pulse rocket motor of the first embodiment of the invention. However, the configuration of the brittle portion **24***c* of the dividing sheet **24** is not limited to the first embodiment.

For example, the dividing sheet **24** of the embodiment is formed by stacking the first and second rubber layers **40** and **41** in which the rubber plates are butt-jointed. However, the second rubber layer may be formed only of the rubber plates whose grain direction is the circumferential direction of the dividing sheet.

Although the second rubber layer **41** of the embodiment is configured by butt-jointing the rubber plate **41***a* whose grain direction is the front-back direction of the dividing sheet **24** and the rubber plate **41***b* whose grain direction is the circumferential direction of the dividing sheet **24**, the grain direction of the rubber plate **41***a* is not limited to the front-back direction and may be another arbitrary direction.

The pulse rocket motor of the second to fifth embodiments different in the configuration of the brittle portion **24***c* will be described below. The pulse rocket motor of the second to fifth embodiments is the same as the pulse rocket motor **1** of the first embodiment in terms of configuration except for the brittle portion. These embodiments have the same advantages as with the first embodiment, so that detailed description will be omitted, and the configuration of the brittle portion of these embodiments will be described in detail.

FIGS. **8**A and **8**B are fragmentary sectional views showing the configuration of the brittle portion of the dividing sheet in the pulse rocket motor according to the second embodiment. The second embodiment will be described with reference to FIGS. **8**A and **8**B.

As shown in FIGS. **8**A and **8**B, the dividing sheet in the second embodiment forms a front rubber layered body **144***a* and a rear rubber layered body **144***b* by stacking rubber plates **140**. These two front and rear rubber layered bodies are butt-jointed together by cure adhesion. This way, the layered faces and butt-jointed faces of the rubber plates **140** are adhered together. The brittle portion **124***c* in the second embodiment is a portion in which a pair of front and rear rubber layered bodies, namely, the front rubber layered body **144***a* and the rear rubber layered body **144***b* forming the dividing sheet, are butt-jointed by cure adhesion. The butt-jointed faces of the front rubber layered body **144***a* and the rear rubber layered body **144***b* form a staircase pattern so as to be engaged with each other. The stair-like boundary faces adhered to each other function as the brittle portion **124***c*. In other words, since the front rubber layered body **144***a* and the rear rubber layered body **144***b* are butt-jointed to each other, fibers contained inside the rubber plate **140** are cut off in the adhesion boundary faces, which makes the boundary faces more brittle than other portions.

FIG. **9** is a fragmentary sectional view showing the configuration of the brittle portion of the dividing sheet in the pulse rocket motor according to the third embodiment. The third embodiment will be described with reference to FIG. **9**.

A brittle portion **224***c* of the third embodiment is a portion formed by folding a rubber layered body **244** forming the dividing sheet as shown in FIG. **9**.

More specifically, the rubber layered body **244** is obtained by stacking rubber plates **240** whose grain direction in which fibers **242** are aligned is the front-back direction. In the brittle portion **224***c*, the rubber layered body **244** is folded twice. The folded portion is projecting inwards as viewed in the inner circumferential portion of the dividing sheet. Release sheets **246** (such as fluorine resin sheet) for preventing cure adhesion between the rubber plates are sandwiched between the respective contacting faces of the folded rubber layered body **244**. The folded portion is compressed and vulcanized in a thickness direction with the release sheets **246** sandwiched between the contacting faces.

When the brittle portion **224***c* formed of the folded portion receives the combustion pressure created during the second pulse, and the dividing sheet **24** is then stretched in the front-back direction, the portions sandwiching the release sheets **246** and thus being not adhered together start expanding. As the result, stress is focused on a curved portion **248** that is curved in an arc-like shape. When the stress reaches a predetermined or higher value, the curved portion **248** is broken.

In the brittle portion **224***c* of the third embodiment, the curved portion **248** on which stress is focused is formed by folding the rubber layered body **244**, thereby forming the brittle portion **224***c* that is more brittle than other portions.

FIG. **10** is a fragmentary sectional view showing the configuration of the brittle portion of the dividing sheet in the pulse rocket motor according to the fourth embodiment. The fourth embodiment will be described with reference to FIG. **10**.

As shown in FIG. **10**, a brittle portion **324***c* of the fourth embodiment is a portion in which a rubber layered body **344***c* whose grain direction is a circumferential direction is sandwiched between a pair of front and rear rubber layered bodies **344***a* and **344***b* whose grain direction is the front-back direction.

More specifically, the middle rubber layered body **344***c* whose grain direction is the circumferential direction is situated between the front rubber layered body **344***a* and the rear rubber layered body **344***b* whose grain direction in which fibers **342** are aligned is the front-back direction. Boundary faces of the front rubber layered body **344***a*, the rear rubber layered body **344***b* and the middle rubber layered body **344***c* are butt-jointed together by cure adhesion. These butt-jointed boundary faces are concave-convex surfaces in which the rubber plates **340** are alternately projecting and recessed so that the rubber layered bodies **344***a*, **344***b* and **344***c* may be engaged with each other.

When receiving the combustion pressure created during the second pulse, the dividing sheet **24** expands in the front-back direction. The front and rear rubber layered bodies **344***a* and **344***b* whose grain direction is the front-back direction therefore have much strength against the combustion pressure. The middle rubber layered body **344***c* whose grain direction is the circumferential direction orthogonal to the front-back direction is sensitive to expansion in the front-back direction, and is broken along the fibers **342** ahead of the front and rear rubber layered bodies **344***a* and **344***b*. In the fourth embodiment, the brittle portion **324***c* that is more brittle than other portions is formed by setting the aligning direction of the fibers **342** (grain direction) contained in the rubber plates **340** to be a direction in which the fibers **342** are easily broken.

FIG. **11** shows a modification example of the fourth embodiment.

According to the modification example, release sheets **346** (such as fluorine resin sheet) for preventing cure adhesion between the rubber plates are sandwiched between the layered faces of the rubber plates **340** of the middle rubber layered body **344***c*, thereby preventing the rubber plates from being adhered to each other at the time of molding the middle rubber layered body **344***c*. This makes the middle rubber layered body **344***c* easy to break. If the release sheets **346** are used to prevent the layered faces of the rubber plates **340** from being adhered to each other, it is possible to adjust the strength of a brittle portion **324***c*' and break the dividing sheet with proper timing in the second pulse.

FIG. **12** is a fragmentary sectional view showing the configuration of the brittle portion of the dividing sheet in the pulse rocket motor according to the fifth embodiment. The fifth embodiment will be described with reference to FIG. **12**.

As shown in FIG. **12**, a brittle portion **424***c* of the fifth embodiment is a portion in which a pair of front and rear rubber layered bodies **444***a* and **444***b* has an intervening member **450** there between, which is made of different material from the rubber layered bodies **444***a* and **444***b*.

More specifically, the intervening member **450** is situated between the front rubber layered body **444***a* and the rear rubber layered body **444***b* whose grain direction in which fibers **442** are aligned is the front-back direction. Boundary faces of the front rubber layered body **444***a*, the rear rubber layered body **444***b* and the intervening member **450** are butt-jointed by cure adhesion. The butt-jointed boundary faces are concave-convex surfaces in which the rubber plates **440** of the rubber layered bodies **444***a* and **444***b* are alternately projecting and recessed so that the rubber layered bodies **444***a* and **444***b* and the intervening member **450** may be engaged with each other.

The intervening member **450** is made, for example, of rubber that is free of fibers or the like or heat-resistant resin (heat-resistant engineering plastic) and is made of material that is more sensitive to expansion in the front-back direction and easier to break at least than the rubber layered bodies **444***a* and **444***b*. If the dividing sheet receives the combustion pressure created during the second pulse and expands in the front-back direction, the intervening member **450** is broken ahead of the rubber layered body **444***a* and **444***b*. In other words, the brittle portion **424***c* of the fifth embodiment is formed to be more brittle than other portions by placing the intervening member **450** low in strength between the rubber layered bodies **444***a* and **444***b*.

This is the end of the description of the embodiments of the pulse rocket motor according to the invention. However, embodiments are not limited to the foregoing ones.

Loads of the first and second grains **6** and **8** and the like are not limited to those mentioned in the above embodiments, and may be properly determined depending on the intended use. For example, the entire first grain may be formed in the shape of a hollow cylinder or a cylinder including a portion having a cross-section with vertices.

Although the pressure vessel **2** of the embodiments is of a bi-split type, the invention may be applied to a non-splitable pressure vessel that is integrally formed into a single body.

In the above embodiments, the rubber layered body forming the dividing sheet is formed of the four rubber layers **40** and **41**. The number of the rubber layers of the rubber layered body, however, is not limited and may be more or less than the foregoing number.

According to the above embodiments, the dividing sheet **24** is formed to expand from the inner face **24***a* of the second grain **8** through the end face **24***b*. However, the dividing sheet **24** is only required to expand along the inner face **24***a* of the second grain **8** and cover the second grain **8**. For example, if the pressure vessel is provided inside with an inner wall for separating the first grain from the second grain, the dividing sheet is provided only to the inner face, which expands along the inner circumference of the second grain. The dividing sheet is then provided with dividing sheet clamps at both sides. The dividing sheet clamp located near the front end is fixed to a front dividing wall of the pressure vessel, and the dividing sheet clamp located near the rear end is fixed to the inner wall for separating the first grain from the second grain.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. A pulse rocket motor comprising:

a first grain having a hollow cylinder-like shape and situated in a rear section of a pressure vessel;

a first igniter that ignites the first grain;

a second grain having a hollow cylinder-like shape and situated in a front section of the pressure vessel;

a second igniter that ignites the second grain; and

a dividing sheet member that covers the second grain within the pressure vessel, wherein:

the dividing sheet member has a dividing sheet expanding at least along an inner circumferential surface of the second grain, and holders formed integrally with the dividing sheet at both ends of the dividing sheet by cure adhesion and attached to the pressure vessel; and

the dividing sheet includes a brittle portion that expands along the inner circumferential surface of the second grain through a rear end face of the second grain and is more brittle than other portions.

2. The pulse rocket motor according to claim **1**, wherein: the dividing sheet is curved along an inner circumferential surface of the second grain through the rear end face of the second grain, and the brittle portion is formed around the curved portion.

3. The pulse rocket motor according to claim **1**, wherein: the dividing sheet is a rubber layered body in which rubber plates containing fibers are stacked in layers in a thickness direction; and

the brittle portion is a portion in which first rubber layers, each of which includes a pair of butt-jointed rubber plates whose grain direction is a front-back direction of the dividing sheet member, and second rubber layers, each of which includes butt-jointed a rubber plate whose grain direction is an arbitrary direction and a rubber plate whose grain direction is a circumferential direction of the dividing sheet member, are alternately stacked in layers; butt-jointed faces of the first rubber layers lay in the same plane; and the rubber plate lay in the same plane whose grain direction, except for the grain direction of the butt-jointed faces, is the circumferential direction of the dividing sheet member.

4. The pulse rocket motor according to claim **1**, wherein: the dividing sheet is a rubber layered body in which rubber plates are stacked in layers in a thickness direction; and

the brittle portion is a portion in which the front and rear rubber layered bodies are butt-jointed together by cure adhesion.

5. The pulse rocket motor according to claim **1**, wherein: the dividing sheet is a rubber layered body in which rubber plates are stacked in layers in a thickness direction; and

the brittle portion is a portion in which the rubber layered body is folded.

6. The pulse rocket motor according to claim **1**, wherein: the dividing sheet is a rubber layered body in which rubber plates in which fibers are mixed and aligned in a grain direction are stacked in layers in a thickness direction; and

the brittle portion is a portion in which a rubber layered body obtained by stacking rubber plates whose grain direction is a circumferential direction of the dividing sheet member is sandwiched between front and rear rubber layered bodies in which rubber plates whose grain direction is a front-back direction of the dividing sheet member are stacked in layers.

7. The pulse rocket motor according to claim **6**, wherein: in the rubber layered body obtained by stacking the rubber plates whose grain direction is the circumferential direction of the dividing sheet member, layered faces of the rubber plates are not adhered to each other.

8. The pulse rocket motor according to claim **1**, wherein: the dividing sheet is a rubber layered body in which rubber plates are stacked in layers in a thickness direction; and

the brittle portion is a portion in which a pair of front and rear rubber layered bodies has an intervening member there between, which is made of material different from the rubber layered bodies.

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